

## CLINICAL ARTICLE

# Surgical Management for Avulsion Fracture of the Calcaneal Tuberosity

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**Objective:** To discuss the operative methods and curative effect of calcaneal tuberosity fracture.

**Methods:** A retrospective study was done to analyze 15 patients with calcaneal tuberosity fracture who received surgical management between January 2008 and June 2011. There were nine males and six females, with the age ranging from 31 to 68 years (average, 51.4 years). All the patients had unilateral acute injury, with the left foot in 7 cases and the right foot in 8 cases. According to the Beavis classification, there were three cases in type I and 12 cases in type II. All the cases in type I and 10 cases in type II were treated with open reduction and screw fixation. The other two cases in type II with larger fragment involving a portion of the subtalar joint were treated with plate and screw fixation. The effect of the treatment was assessed according to the ankle and hindfoot score system of American Orthopaedic Foot and Ankle Society (AOFAS) after the operation.

**Results:** Ten patients were followed up for 12 to 36 months (average, 20 months). The healing time in these patients ranged from 8 to 25 weeks (average, 12 weeks). The postoperative score ranged from 47 to 100 points (average, 91.1 points). Seven cases were rated as excellent, two as good, and one as poor. The rate of excellent and good was 90%. Necrosis of skin and soft tissue and exposure of the plate happened in one patient, who eventually healed after 3 weeks by debridement with plate preserved and peroneal artery perforator flap transplantation. Loss of reduction happened to another patient, who was treated with revision surgery by open reduction and screw fixation again.

**Conclusion:** To patients with obvious fracture displacement, whose soft tissues are irritated severely, emergency open reduction and internal fixation operation should be offered to prevent the necrosis of the flaps as far as possible. To patients with small fractures, it is advisable to choose open reduction and large diameter screw fixation, while plate and screw fixation may be better for the patients with large fragments, especially for those with the fracture line extending to the subtalar joint.

**Key words:** Calcaneus; Fracture fixation; Fractures; Internal; Internal fixators

## Introduction

The calcaneal tuberosity is an important part of the heel which plays an important role in maintaining the foot arch and buffering the load. Avulsion fracture of the calcaneal tuberosity frequently occurs in the elderly and athletes<sup>1</sup>. However, the incidence of isolated calcaneal tuberosity avulsion fracture is low, accounting for only 1.3% to 2.7% of all calcaneal fractures<sup>2</sup>.

The management for avulsion fracture of the calcaneal tuberosity can be classified into conservative or surgical treatment. Surgical treatment is mainly applicable to patients with larger fracture fragments and significant displacement, especially for those with severe soft tissue irritation. Early surgical treatment helps to reduce the incidence of soft tissue necrosis and restore the normal functions of the triceps

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**TABLE 1** The general data and treatment outcomes of the 15 cases of avulsion fracture of the calcaneal tuberosity

Case	Gender	Age (years)	Fracture site	Interval from injury to operation (d)	Complications	Second operation	Healing time (weeks)	AOFAS scores
1	M	34	Left calcaneal tuberosity with involvement of subtalar facet	5	Skin necrosis; Plate exposure	Debridement; Peroneal artery perforator flap transplantation	16	84
2	F	47	Left calcaneal tuberosity; Soft tissue irritation	Emergency	No	No	12	98
3	M	55	Right calcaneal tuberosity	2	No	No	10	100
4	M	62	Right calcaneal tuberosity	1	No	No	12	98
5	F	45	Left calcaneal tuberosity with involvement of subtalar facet	5	Skin necrosis	No	14	89
6	F	57	Left calcaneal tuberosity	3	No	No	12	97
7	M	68	Right calcaneal tuberosity	2	No	No	12	98
8	M	39	Right calcaneal tuberosity; Soft tissue irritation	Emergency	No	No	8	100
9	M	46	Right calcaneal tuberosity	2	Loss of reduction	Re-ORIF with two 6.5 mm cannulated screws	25	47
10	F	44	Left calcaneal tuberosity	1	No	No	9	100
11	M	31	Right calcaneal tuberosity	2	—	—	—	—
12	M	58	Left calcaneal tuberosity	3	—	—	—	—
13	F	61	Right calcaneal tuberosity	2	—	—	—	—
14	F	59	Left calcaneal tuberosity	2	—	—	—	—
15	M	65	Right calcaneal tuberosity	1	—	—	—	—

surae and the foot, which is of great significance for the rehabilitation<sup>3</sup>.

However, incorrect surgical indications and the surgery time for this type of fracture, or unsuitable implants, will frequently lead to a series of postoperative complications such as skin flap necrosis and implant failure, which may cause non-union or malunion of calcaneal tuberosity fractures and affect the early ambulation<sup>4,5</sup>.

In this study, we retrospectively analyzed 15 cases of avulsion fracture of the calcaneal tuberosity in order to summarize the surgical strategies for this fracture and to analyze the reasons and countermeasure of postoperative implant failure and wound complications.

## Materials and Methods

### General Information

Data from 15 patients (9 males and 6 females) with an average age of 51.4 years (range, 31 to 68 years) who had calcaneal tuberosity fractures and underwent open reduction and internal fixation from January 2008 to June 2011, were retrospectively analyzed. All the cases had an acute unilateral injury, among which seven cases had left foot injury, while eight cases had right foot injury. The reasons for the fractures included: (i) direct loading to the calcaneal tuberosity due to falling from height with ankle dorsiflexion in eight cases; (ii) the calcaneal tuberosity hit the posterior malleolus and fractured from the direct impact while tripping with extensive plantar flexion of the ankle joint in three cases; (iii) the calcaneal tuberosity were

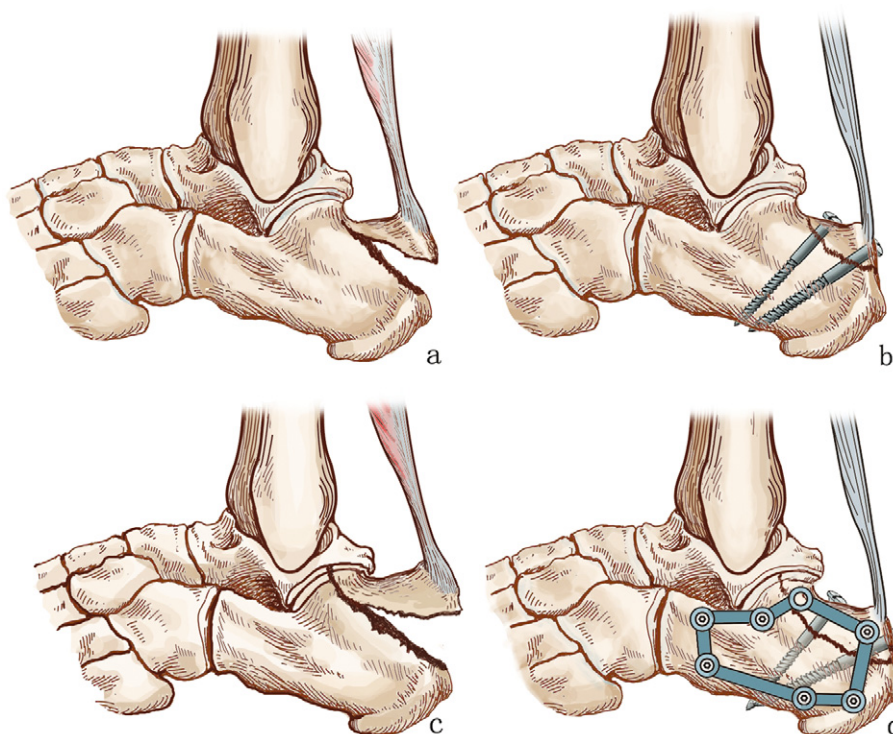
fractured by direct compaction from vehicle accident in three cases; and (iv) bearing all the body weight on unilateral calcaneal tuberosity when accidentally taking a missed step on the stairs in one case (Table 1).

All patients suffered from closed fracture with clinical symptoms such as heel pain, local swelling, ecchymosis formation, and difficulties in shoe-wearing and walking. Bony eminence at the calcaneal tuberosity concomitant pale skin and blister formation were observed in two cases. The visual analogue scale (VAS) was used for evaluating the pain caused by fracture. All patients reported pain of moderate or worse degree. A total of three cases had a score of 4 to 6, while 12 cases had a score of 7 to 10; the average score was 7.8.

Pre-operative X-ray imaging of the lateral and axial projections of calcaneus, anteroposterior and oblique projections of the foot, and CT scanning with three-dimensional reconstruction were taken. According to the Beavis classification<sup>6</sup>, there were three cases of Beavis type I fracture and 12 cases of Beavis type II fracture. In two cases, the fracture fragments were relatively large with the fracture lines obliquely extending from below the Achilles tendon to the posterior articular facet of the subtalar joint. However, there were no patients of the Achilles tendon injury.

### Surgical Techniques

For the two cases with obvious displacement of the fragments, symptoms of soft tissue irritation were expected. Therefore, emergent operation was performed within 8 hours after the injury. For two cases, the operation was performed 5 days after



**Fig. 1** The schematic diagrams of the operations. (a) Avulsion fracture of the calcaneal tuberosity without involving the subtalar facet. (b) Two screws were placed. Attention should be paid that one screw should be placed perpendicular to the fracture line to penetrate the contralateral cortex and the other screw was placed perpendicular to the Achilles tendon to resist the traction forces of the Achilles tendon. (c) The avulsion fracture of calcaneal tuberosity with the subtalar facet being involved. (d) One or two lag screws were used to stabilize the fragments. In order to provide a stable fixation, a calcaneal plate was also used to strengthen the fixation of the fragments.

the injury because of the involved subtalar joint and swelling. For the other 11 patients, the operation was delayed from one to three days.

Continuous epidural anesthesia was adopted, and the patients were positioned laterally.

If the fracture fragments were small and did not involve the subtalar facet (Fig. 1a), posteromedial, posterolateral, or posterior midline longitudinal incisions of the heel could be selected based on the shape of the fracture fragment and the direction of the displacement. In this study, of the 13 patients with small fracture fragments, three cases underwent the operation through a posteromedial longitudinal incision, five cases through a posterolateral longitudinal incision, and the remaining five cases through a posterior midline longitudinal incision. The skin and fascia were incised to expose the fracture fragments of the calcaneal tuberosity. The Achilles tendon insertion was examined intraoperatively. A reduction clamp was used to reduce the avulsion fracture fragment of the calcaneal tuberosity. Two Kirschner wires were used for temporary fixation. After good reduction was confirmed by fluoroscopy, the avulsion fracture fragment of the calcaneal tuberosity was fixated using two 4.5 mm or 6.5 mm lag screws. Attention should be paid that one screw should be placed

perpendicular to the fracture line to penetrate the contralateral cortex and the other screw was placed perpendicular to the Achilles tendon to resist the traction forces of the Achilles tendon (Fig. 1b).

For patients with larger fracture fragments which involved the subtalar facet (Fig. 1c), the modified lateral L-shaped incision was used. In this study, the skin and fascia were incised to expose the subtalar joint for two cases, and then one or two lag screws were used to stabilize the fragments. In order to provide a stable fixation, a calcaneal plate was also used to strengthen the fixation of the fragments (Fig. 1d).

After the fixation was satisfied by the intraoperative fluoroscopy, the wounds were closed in the usual manner. However, relaxation suture was used if the skin tension was strong. If the incision closure was difficult or skin and soft tissue necrosis occurred postoperatively, local flap transfer or skin graft was considered to close the wound.

#### **Postoperative Management**

Postoperatively, the affected limb should be elevated. For cases without subtalar facet involvement, short leg plaster splint was used in plantar flexion for three weeks. However, for cases

with subtalar facet involvement, the fixation time should be extended till six weeks. Non-weight-bearing functional exercise of the ankle could be started after the plaster was removed. X-ray imaging was performed 10 to 12 weeks after the operation. Partial weight-bearing walking was allowed if bone healing was confirmed. However, the principle of weight-bearing without pain should be first obeyed. Full weight-bearing was allowed after 14 weeks postoperatively.

### Function Assessment

The American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot scale was used to evaluate the postoperative functional outcomes. The scale includes three aspects; pain, function, and alignment. The total score was 100 for this scale. A score of 90–100 indicates excellent, 80–89 good, 70–79 fair, and less than 70 poor.

### Results

Ten patients were followed up over a period of 12 to 36 months (average of 20 months). X-ray imaging with anteroposterior view, lateral view of weight-bearing as well as axial view were taken to examine the fracture healing status. After the operation, seven patients obtained favorable outcomes without complications such as healing problems, loss of reduction, and fixation failure. These seven cases eventually achieved healing from 8 to 12 weeks (average of 10.7 weeks) postoperatively, and all of them could walk with full weight-bearing at the 12th week. The shapes of the feet were normal, and could wear ordinary shoes without obvious pain and discomfort.

Two cases with larger fracture fragments and subtalar facet involvement underwent plate-screw fixation. Tight sutures were performed though the high skin tension existed, resulting in the poor wound healing. One patient healed three weeks after dressing changes. Another patient suffered from skin flap necrosis and plate exposure. After debridement and peroneal artery perforator flap transplantation with the plate being retained, the wound healed three weeks later and an AOFAS score of 84 was obtained at the 12 month follow-up. The fracture healed completely at the 18th month postoperatively and then the implant was removed (Fig. 2).

One patient still showed symptoms of pain and walking difficulties due to strong traction forces of the Achilles tendon associated with early ambulation 7 weeks postoperatively. Three months postoperatively, X-ray imaging showed re-displacement of the fragment. Re-open reduction and internal fixation with two 6.5 mm cannulated screws was performed and the patient finally obtained complete healing 25 weeks after the initial operation (Fig. 3).

In this study, the AOFAS scores ranged from 47 to 100 with an average of 91.1 in the follow-up at the 12th month. There were excellent scores in seven cases, good in two cases, and poor in one case. The rate of excellent and good scores was 90% (9/10).

### Discussion

#### *Clinical Symptoms of Avulsion Fracture of the Calcaneal Tuberosity*

Avulsion fracture of the calcaneal tuberosity may not have typical clinical symptoms. A minor number of patients with subtle injury may only present symptoms of local swelling and slight pain of the heel. Injury of the calcaneal tuberosity without obvious displacement can be easily confused with calcanodinia<sup>7</sup>. Patients with fractures of the processes of medial or lateral of the calcaneal tuberosity may suffer from heel pad tenderness, ecchymosis, swelling, and difficulties in standing. In patients with larger fracture fragment and obvious displacement, bony eminence of the heel and severe soft tissue irritation may be observed. Therefore, the soft tissue of the heel must be carefully evaluated during physical examination. When open injury, pale skin, or tension vesiculation occurs, emergent surgery must be performed<sup>8</sup>. Since fractures of the calcaneal tuberosity are often concomitant with Achilles tendon injury, Achilles tendon injury should be considered if the weakness and sense of emptiness of the heel are present. If the whole foot swelling, widening, height decrease, and varus and valgus deformities of the hindfoot are present, a combination of other parts of the calcaneal fractures should be considered.

#### *Management Strategies of Avulsion Fracture of the Calcaneal Tuberosity*

Simple calcaneal tuberosity avulsion fracture can often be treated conservatively, which consists of fixation in a non-weight-bearing position for 3–4 weeks using a plaster splint in an equinus position, followed by maintenance with plaster cast or progressive weight-bearing in padded shoes for 3–4 weeks. Most patients can achieve good results. Inappropriate conservative treatment, however, can cause a series of complications such as persistent pain in the attachment region of Achilles tendon, swelling, ankle stiffness, and plantar flexion weakness, resulting in inconvenience in the patient's daily life.

For avulsion fracture of the calcaneal tuberosity of larger fracture fragments with the displacement of more than 1 cm or fractures with Achilles tendon involvement, surgical treatment is commonly required. The surgery should be performed as soon as possible. In this study, two patients were treated with emergency operation due to the symptoms of bony eminence and pale skin. Skin necrosis was avoided after effective interventions were taken. However, if emergency operation cannot be performed for objective reasons, manipulative reduction and plaster fixation in an equinus position should first be used to stabilize the fracture to avoid the soft tissue irritation as far as possible. Once the surgical conditions are suitable, operation should be performed immediately. Surgical management of avulsion fracture of the calcaneal tuberosity include screw fixation, plate fixation, Kirschner tension band wiring fixation, anchor screw fixation, external fixation and fracture fragment excision. Each of them has certain indications. For example, the screw is mainly used in most simple avulsion fractures of



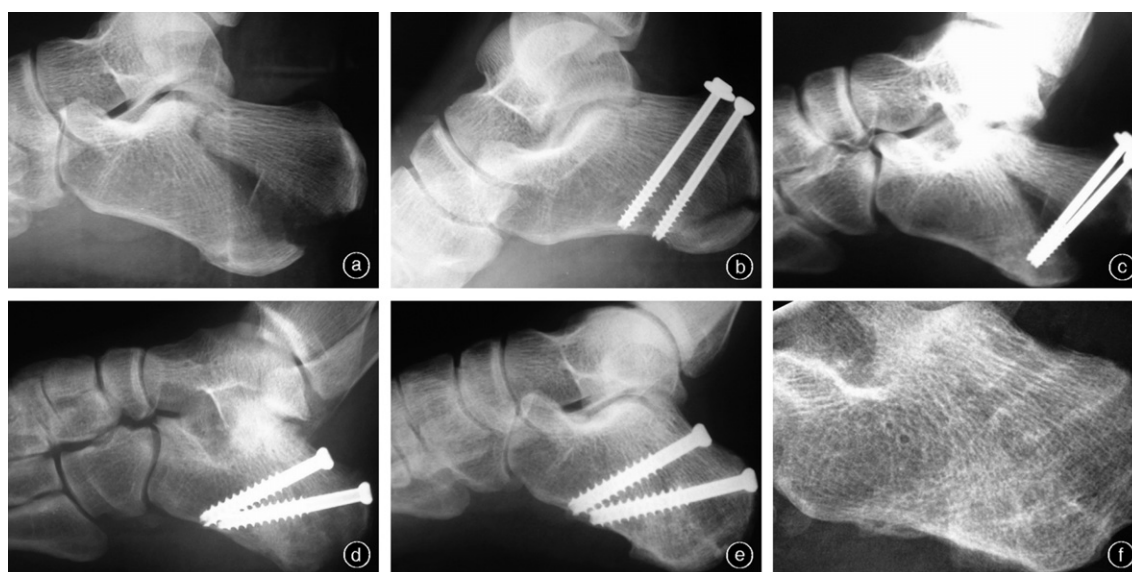


**Fig. 2** (a, b) A 34-year-old male fell from a height and resulted in avulsion fracture of the calcaneal tuberosity in the left foot and the fracture line extended to the subtalar facet. (c, d) Two lag screws were used to stabilize the fragments and then the calcaneal plate was used to strengthen the fragments. (e, f) The fracture healed completely 18 months postoperatively and then the implant was removed.

the calcaneal tuberosity, however, if the fragments are large with the subtalar facet being involved, use of a plate is recommended. The anchor screw is mainly applicable to the small fracture fragments that involve the Achilles tendon and cannot be fixated with other implants. Kirschner tension band wiring is suitable for the large fracture fragments without Achilles tendon injury, however, the junction of the pin tail and wire is likely to cause intense stimulus to the peroneal tendons and skin<sup>9</sup>. An external fixator is applicable to the poor soft tissue when open reduction and internal fixation are inapplicable<sup>10</sup>. Fracture fragment excision is mainly applicable to small obsolete fracture fragments with obvious symptoms, which are not in the attachment region of the Achilles tendon in calcaneal tuberosity.

### ***Surgical Attentions of the Avulsion Fracture of Calcaneal Tuberosity***

Open reduction and screw fixation is preferred in the surgical management for avulsion fracture of the calcaneal tuberosity. Either posteromedial, posterolateral, or posterior midline longitudinal incisions can be chosen. However, if the fracture fragment is large or skin injury is present in the incision area, transverse incision may be the optimal option, as suggested by Eren *et al.*<sup>11</sup>, which can fully expose the fragments while reducing the incidence of wound complications. Since resistance to traction by the triceps surae is required, fixation with a single screw should be avoided. One screw alone is not only insufficient to resist the rotation of the fracture fragments, but may also cause tilting of one end of the fracture fragment.



**Fig. 3** A 46-year-old male was injured in a traffic accident resulting in avulsion fracture of the calcaneal tuberosity in the left foot. (a) The skin and soft tissue was irritated because of the larger fragments. (b) Two 4.5 mm cannulated screws were parallel placed and perpendicular to the fracture line to stabilize the fragments. (c) The loss of reduction was found at the follow-up period of 3 months postoperatively due to the early ambulation. (d) Re-ORIF was performed and two 6.5 mm cannulated screws were used. One screw was placed perpendicular to the fracture line and the other screw was placed perpendicular to the Achilles tendon. (e) The calcaneal obtained bony healing at the follow-up period of 1 year postoperatively. (f) The two screws were removed.

Additionally, it should also be noted that the diameter of the selected screw should be large, preferably with a diameter of more than 4.5 mm. During the fixation, one to two screws should preferably be placed perpendicular to the Achilles tendon by penetrating the fracture fragments into the calcaneus to resist muscle traction and an additional one to two screws should be placed perpendicular to the fracture line to achieve optimized compression between fracture fragments. Furthermore, the screw should preferably penetrate the contralateral cortical bone without injuring the soft tissue of the posterior zone of the heel. Of the cases in this study, one patient in which the fracture fragment was fixated with two 4.5 mm cannulated screws underwent loss of reduction due to Achilles tendon traction caused by earlier ambulation. After the second surgery with two 6.5 mm cannulated screws used, the fracture finally healed.

To maintain reduction of the fracture fragment of the calcaneal tuberosity, the patient should be immobilized by plaster in plantar flexion for 4 to 6 weeks. Conditions of the heel skin and soft tissue were observed regularly after the operation. When X-ray imaging indicated bony healing of the fracture fragment, the patient was allowed to take a weight-bearing walk and perform early functional exercise of the ankle to prevent gastrocnemius contracture as described before<sup>12</sup>.

The management of the simple calcaneal tuberosity fracture by plate fixation has not been widely reported in clinical practice. However, for patients with comminuted fractures of the calcaneal tuberosity caused by severe osteoporosis or with

larger fracture fragments, especially with the fracture line extending to the subtalar facet, which the screws and tension bands cannot provide sufficient stability, the plate-screw fixation is more appropriate. In this study, two cases of the avulsion fracture of calcaneal tuberosity with subtalar facet involvement were treated with the plate-screw fixation. A modified lateral L-shaped incision was made to expose the subtalar joint and then the joint surface was reduced and fixated with 1–2 screws from the calcaneal tuberosity along the fracture line. Finally, the fracture fragments were fixated firmly by an additional calcaneal plates. Postoperative imaging showed a good reduction without displacement of the subtalar facet.

#### **Prevention of Wound Complications**

If the operation is performed in cases of serious soft tissue irritation or with incision too near to the open wound or with strong skin tension, the tight suture will affect the blood supply of the incisions. In addition, previous studies have shown that small arteries that supply the calcaneal tubercle and the bone-tendon junction of the Achilles tendon are mainly terminal branches, which rarely converge with each other to form arterial networks. Furthermore, the number of these blood vessels decreases with age. Thus, blood supply in this region can become worse with age<sup>13</sup>. Consequently, the calcaneal tuberosity surgery often causes the wound complications. In this study, two cases with strong skin tension after plate-screw fixation were sutured tightly. As a result, the skin and soft tissue healed poorly. One patient healed after regular dressing-

changing at 3 weeks. For the other patient, necrosis of the skin and soft tissue occurred and the plate was exposed, and eventually healed after 3 weeks by debridement with plate preserved and peroneal artery perforator flap transplantation. Therefore, reasonable option of the surgery time and type of surgical

incision are crucial to avoid wound complications effectively. Skin and soft tissue must be evaluated before wound closure. In cases in which suturing is difficult due to strong skin tension, relaxation suture and vacuum sealing drainage (VSD) can be performed to promote a better wound healing.

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